Space Weather Technical Forecast

Issued on Sunday, 28 May 2023 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1/R2 radio blackouts likely. Active electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low to Moderate, with one M1.0 flare observed from AR3315 AT 28/1036 UTC. There were also a couple moderate C-class flares observed from AR3311 and AR3314 in the northwest. There are currently 8 regions on the visible disc with a region in the southeast coming and going in the period. AR3315 (Ekc/Beta-Gamma-Delta) is the largest region on the disc and it is magnetically complex, with perhaps 2 delta spots. AR3314 (Dai/Beta-Gamma-Delta) in the northwest is also magnetically complex, containing a delta spot, but it is significantly smaller. AR3311 (Fao/Beta-Gamma) is also a region of note being in beta-gamma formation but it is rather long and open. All other regions on the disc are either small or simple.
Two CMEs were observed during the period, one from the east limb from 27/1215 UTC and one to the south from 27/2000 UTC. Both of these are thought not to be Earth directed.

Solar Wind / Geomagnetic Activity: Solar winds observed at L1 have been slightly elevated between 400 and 500 km/s. The density has been below average (<5 ppcc). Total interplanetary magnetic field strength has been weak (<6 nT). The north-south component has been predominantly negative since 27/1500 UTC, all be it weak. The phi angle was mostly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV at GOES-16) has remained at background levels throughout. High energy electron flux (greater than 2MeV at GOES-16) was at high levels, peaking at 4250 pfu at 27/1710 UTC, but erratically dropped to background levels from 28/0200 UTC. The associated 24 hour fluence was Active (above 1e8 integrated pfu) but has begun to decline from a peak of 2.65e8 integrated pfu at 28/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with the main risk of flare activity from AR3315. There is a slight chance of X-class flaring throughout.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 25th May could glance the Earth on 29th May. A further feature which left the Sun on 26th May could glance Earth late on 30th or 31st May. Solar winds are likely to remain slightly elevated through much of the forecast period due to slight enhancements from coronal hole 06 and then 07. Geomagnetic activity is expected to be mainly Quiet to Unsettled, but with a risk of Active or G1/Minor Storms on both 29th-31st May due to potential CME impacts.

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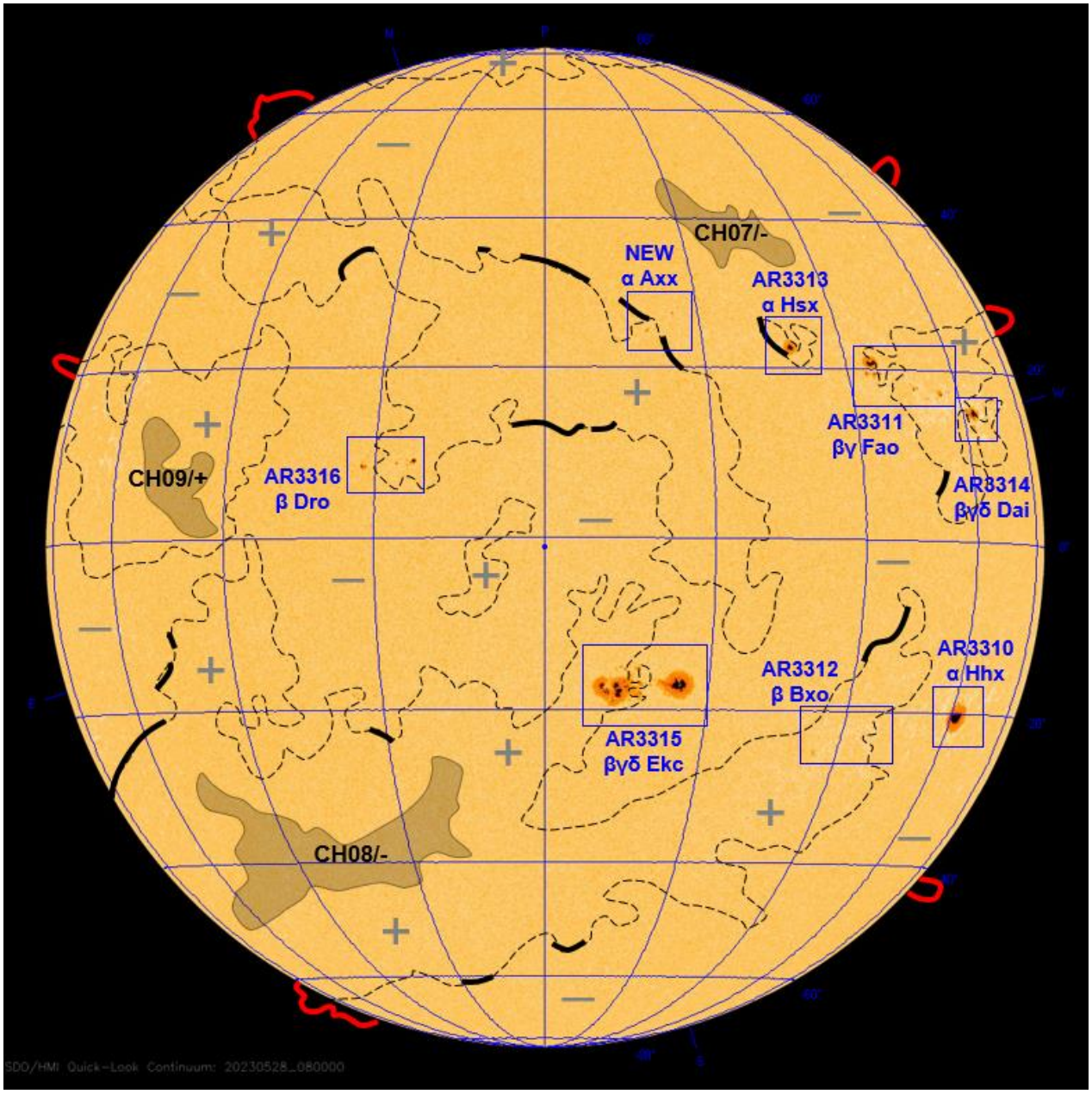
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels. There is a slight chance of reaching the S1/Minor Storm threshold should any larger flares occur, mainly from AR3315. High energy electron flux (greater than 2MeV) is expected to be at moderate to high levels through much of the period. The forecast CME arrivals and high speed stream connections could generate enough geomagnetic activity reduce electron counts, but with limited confidence. Electron fluence values are expected to remain above the Active (1e8 integrated pfu) threshold, but with decreasing confidence later in the period due to the uncertainty of modifying factors.

Figure 1. Solar Analysis Valid 28/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CMEs in the forecast that may glance Earth. An eruption which left the Sun on the 25th May may glance Earth on 29th May (day 2) with a further possible glancing blow late on the 30th or 31st May (days 3 and 4) from an eruption on the 26th May, although much of this second feature is directed southward.

Solar winds are likely to remain slightly elevated through much of the forecast period due to the waning effects of coronal hole 06 followed by some slight enhancement from coronal hole 07. Based on persistence, the high speed stream from coronal hole 07 is likely to connect by the 29th May, following the pattern of the previous rotation. Coronal hole 07 is of a similar shape and size to the last rotation, lending additional credit to this aspect of the forecast and suggesting peak speeds of around 500km/s. On day 4 (31st), solar winds are likely to return to ambient levels as this enhancement declines.

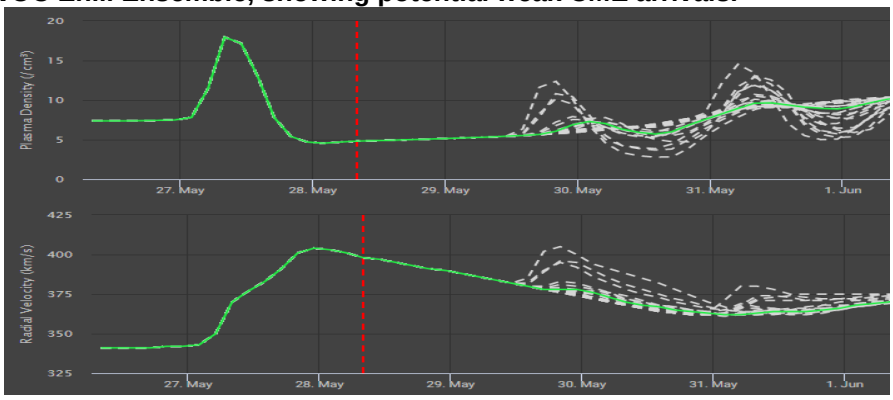
Mainly Quiet geomagnetic activity is forecast, with occasional Unsettled intervals. There is a slight chance of Active or G1/Minor Storms on days 2-4 (29th-31st May) due to the possible glancing impacts from the CMEs mentioned above.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	20	20	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
26/0144	Partial	AR3312	S	347 km/s	Late 29th	Low confidence
27/0525	Partial	Unknown	SE	310 km/s	30th or 31st	Low confidence

Figure 2: MOSWOC Enlil Ensemble, showing potential weak CME arrivals.



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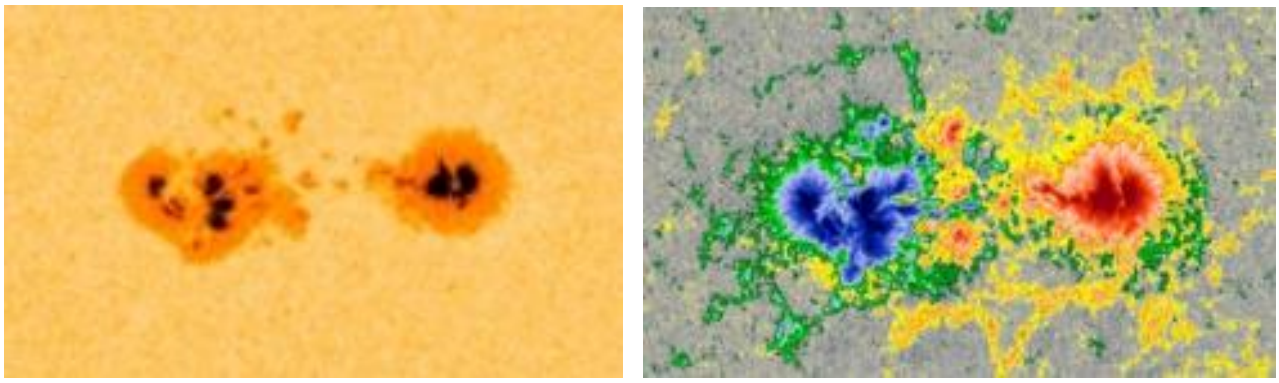
Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate over the past 24 hours, with a single M1 flare observed at 28/1036 UTC. Further isolated M-class flares are considered likely through the forecast period, due to the 3 complex regions in the western hemisphere; AR3311 (Fao/Beta-Gamma), AR3314 (Dai/Beta-Gamma-Beta), AR3315 (Ekc/Beta-Gamma-Delta), and there is a slight chance of an X-flare. AR3315 is particularly large and contains up to 2 delta spots. There are presently 5 other regions on the visible disc, but currently these are either small or simple.
Several regions, some of which may have been responsible for significant activity as they moved across the farside, are due to rotate onto the eastern limb over the next few days and could lead to an increase in solar activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: AR3315 (Ekc/Beta-Gamma-Delta) at 28/0600 UTC.



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at background levels. There is a slight chance of an increase to the S1/Minor Storm level, should any larger flares occur, with AR3315 the most likely source region as it transits the western hemisphere.

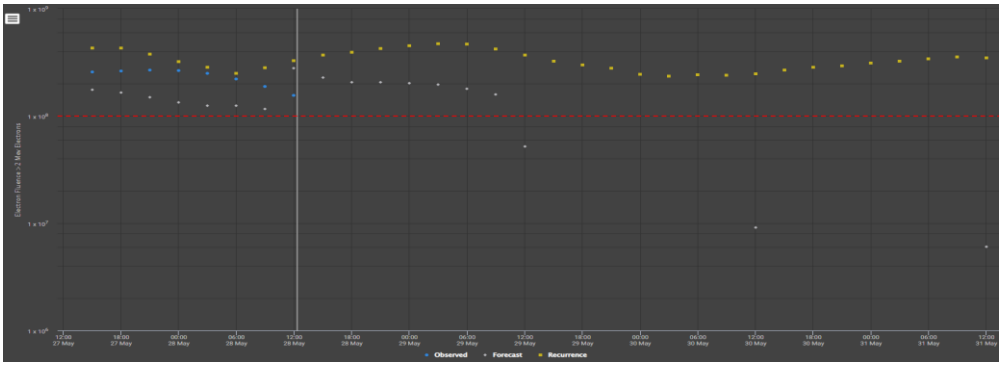
Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at high levels and is likely to return to such levels during diurnal peaks in the absence of any high confidence modifying factors. The most likely source of any geomagnetic activity is from two CMEs on 29th and 31st May, although both these are only likely to glance the Earth at most, resulting in limited geomagnetic activity, and thus provides uncertainty to the forecast.
Associated 24 hour fluence is likely to remain above the Active (1e8 integrated pfu) throughout. The decrease in probabilities later in the period is due to uncertainties around the low confidence CME arrivals.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	80	60	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES-16 electron fluence and REFM data



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